SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

FRIDAY, AUGUST 26, 1904.

CONTENTS:

MSS. intended for publication and books, etc., intended for review should be sent to the Editor of SCIENCE, Garrison-on-Hudson, N. Y.

REFLECTIONS SUGGESTED BY THE NEW THEORY OF MATTER.*

THE meetings of this great society have for the most part been held in crowded centers of population, where our surroundings never permit us to forget, were such forgetfulness in any case possible, how close is the tie that binds modern science to modern industry, the abstract researches of the student to the labors of the inventor and the mechanic. This, no doubt, is as it should be. The interdependence of theory and practice can not be ignored without inflicting injury on both; and he is but a poor friend to either who undervalues their mutual cooperation.

Yet, after all, since the British Association exists for the advancement of science, it is well that now and again we should choose our place of gathering in some spot where science rather than its applications, knowledge, not utility, are the ends to which research is primarily directed.

If this be so, surely no happier selection could have been made than the quiet courts of this ancient university. For here, if anywhere, we tread the classic ground of physical discovery. Here, if anywhere, those who hold that physics is the true *Scientia Scientiarum,* the root of all the sciences which deal with inanimate nature, should feel themselves at home. For, unless I am led astray by too partial an affection for my own university, there is nowhere to be found, in any corner of the

* Address of the President of the British Association for the Advancement of Science, Cambridge, 1904.

world, a spot with which have been connected, either by their training in youth, or by the labors of their maturer years, so many men eminent as the originators of new and fruitful physical conceptions. I say nothing of Bacon, the eloquent prophet of a new era; nor of Darwin, the Copernicus of biology; for my subject to-day is not the contributions of Cambridge to the general growth of scientific knowledge. I am concerned rather with the illustrious line of physicists who have learned or taught within a few hundred yards of this building—a line stretching from Newton in the seventeenth century, through Cavendish in the eighteenth, through Young, Stokes, Maxwell, in the nineteenth, through Kelvin, who embodies an epoch in himself, down to Rayleigh, Larmor, J. J. Thomson, and the scientific school centered in the Cavendish laboratory, whose physical speculations bid fair to render the closing years of the old century and the opening years of the new as notable as the greatest which have preceded them.

Now what is the task which these men, and their illustrious fellow-laborers out of all lands, have set themselves to accomplish? To what end led these 'new and fruitful physical conceptions' to which I have just referred? It is often described as the discovery of the 'laws connecting phenomena.' But this is certainly a misleading, and, in my opinion, a very inadequate, account of the subject. To begin with, it is not only inconvenient, but confusing, to describe as 'phenomena' things which do not appear, which never have appeared, and which never can appear, to beings so poorly provided as ourselves with the apparatus of sense perception. But apart from this, which is a linguistic error too deeply rooted to be easily exterminated, is it not most inaccurate in substance to say that a knowledge of nature's laws is all we seek when investigating nature? The physicist looks for something more than what, by any stretch of language, can be described as 'co-existences' and 'sequences' between so-called 'phenomena.' He seeks for something deeper than the laws connecting possible objects of experience. His object is physical reality: a reality which may or may not be capable of direct perception; a reality which is in any case independent of it; a reality which constitutes the permanent mechanism of that physical universe with which our immediate empirical connection is so slight and so deceptive. That such a reality exists, though philosophers have doubted, is the unalterable faith of science; and were that faith *per impossible* to perish under the assaults of critical speculation, science, as men of science usually conceive it, would perish likewise.

If this be so, if one of the tasks of science, and more particularly of physics, is to frame a conception of the physical universe in its inner reality, then any attempt to compare the different modes in which, at different epochs of scientific development, this intellectual picture has been drawn, can not fail to suggest questions of the deepest interest. True, I am precluded from dealing with such of these questions as are purely philosophical by the character of this occasion; and with such of them as are purely scientific by my own incompetence. But some there may be sufficiently near the dividing line to induce the specialists who rule by right on either side of it to view with forgiving eyes any trespasses into their legitimate domain which I may be tempted, during the next few minutes, to commit.

Let me, then, endeavor to compare the outlines of two such pictures, of which the first may be taken to represent the views prevalent towards the end of the eighteenth century; a little more than a hundred years from the publication of Newton's 'Prin-

cipia,' and, roughly speaking, about midway between that epoch-making date and the present moment. I suppose that if at that period the average man of science had been asked to sketch his general conception of the physical universe, he would probably have said that it essentially consisted of various sorts of ponderable matter, scattered in different combinations through space, exhibiting most varied aspects under the influence of chemical affinity and temperature, but through every metamorphosis obedient to the laws of motion, always retaining its mass unchanged, and exercising at all distances a force of attraction on other material masses, according to a simple law. To this ponderable matter he would (in spite of Rumford) have probably added the so-called 'imponderable' heat, then often ranked among the elements; together with the two 'electrical fluids,' and the corpuscular emanations supposed to constitute light.

In the universe as thus conceived, the most important forms of action between its constituents was action at a distance; the principle of the conservation of energy was, in any general form, undreamed of; electricity and magnetism, though already the subjects of important investigation, played no great part in the whole of things; nor was a diffused ether required to complete the machinery of the universe.

Within a few months, however, of the date assigned for these deliverances of our hypothetical physicist, came an addition to this general conception of the world, destined profoundly to modify it. About a hundred years ago Young opened, or reopened, the great controversy which finally established the undulatory theory of light, and with it a belief in an interstellar medium by which undulations could be conveyed. But this discovery involved much more than the substitution of a theory of light which was consistent with the facts for one which was not; since here was the first authentic introduction* into the scientific world-picture of a new and prodigious constituent—a constituent which has altered, and is still altering, the whole balance (so to speak) of the composition. Unending space, thinly strewn with suns and satellites, made or in the making, supplied sufficient material for the mechanism of the heavens as conceived by Laplace. Unending space filled with a continuous medium was a very different affair, and gave promise of strange developments. It could not be supposed that the ether, if its reality were once admitted, existed only to convey through interstellar regions the vibrations which happen to stimulate the optic nerve of man. Invented originally to fulfil this function, to this it could never be confined. And accordingly, as every one now knows, things which, from the point of view of sense perception, are as distinct as light and radiant heat, and things to which sense perception makes no response, like the electric waves of wireless telegraphy,† intrinsically differ, not in kind, but in magnitude alone.

This, however, is not all, nor nearly all. If we jump over the century which separates 1804 from 1904, and attempt to give in outline the world-picture as it now presents itself to some leaders of contemporary speculation, we shall find that in the interval it has been modified, not merely by such far-reaching discoveries as the atomic and molecular composition of ordinary matter, the kinetic theory of gases, and the laws of the conservation and dissipation of energy, but by the more and more important part which electricity and the ether

* The hypothesis of an ether was, of course, not new. But before Young and Fresnel it can not be said to have been established.

† First known through the theoretical work of Maxwell and the experiments of Herz.

occupy in any representation of ultimate physical reality.

Electricity was no more to the natural philosophers in the year 1700 than the hidden cause of an insignificant phenomenon.* It was known, and had long been known, that such things as amber and glass could be made to attract light objects brought into their neighborhood; yet it was about fifty years before the effects of electricity were perceived in the thunderstorm. It was about 100 years before it was detected in the form of a current. It was about 120 years before it was connected with magnetism; about 170 years before it was connected with light and ethereal radiation.

But to-day there are those who regard gross matter, the matter of everyday experience, as the mere appearance of which electricity is the physical basis; who think that the elementary atom of the chemist, itself far beyond the limits of direct perception, is but a connected system of monads or sub-atoms which are not electrified matter, but are electricity itself; that these systems differ in the number of monads which they contain, in their arrangement, and in their motion relative to each other and to the ether; that on these differences, and on these differences alone, depend the various qualities of what have hitherto been regarded as indivisible and elementary atoms; and that while in most cases these atomic systems may maintain their equilibrium for periods which, compared with such astronomical processes as the cooling of a sun, may seem almost eternal, they are not less obedient to the law of change than the everlasting heavens themselves.

But if gross matter be a grouping of atoms, and if atoms be systems of electrical monads, what are these electrical monads? It may be that, as Professor Larmor has suggested, they are but a modification of the universal ether, a modification roughly comparable to a knot in a medium which is inextensible, incomprehensible and continuous. But whether this final unification be accepted or not, it is certain that these monads can not be considered apart from the ether. It is not on their interaction with the ether that their qualities depend; and without the ether an electric theory of matter is impossible.

Surely we have here a very extraordinary revolution. Two centuries ago electricity seemed but a scientific toy. It is now thought by many to constitute the reality of which matter is but the sensible expression. It is but a century ago that the title of an ether to a place among the constituents of the universe was authentically established. It seems possible now that it may be the stuff out of which that universe is wholly built. Nor are the collateral inferences associated with this view of the physical world less surprising. It used, for example, to be thought that mass was an original property of matter, neither capable of explanation nor requiring it; in its nature essentially unchangeable, suffering neither augmentation nor diminution under the stress of any forces to which it could be subjected; unalterably attached to, or identified with, each material fragment, howsoever much that fragment might vary in its appearance, its bulk, its chemical or its physical condition.

But if the new theories be accepted these views must be revised. Mass is not only explicable, it is actually explained. So far from being an attribute of matter considered in itself, it is due, as I have said, to the relation between the electrical monads of which matter is composed and the ether in which they are bathed. So far from being unchangeable, it changes, when mov-

* The modern history of electricity begins with Gilbert but I have throughout confined my observations to the post-Newtonian period.

ing at very high speeds, with every change in its velocity.

Perhaps, however, the most impressive alteration in our picture of the universe required by these new theories is to be sought in a different direction. We have all, I suppose, been interested in the generally accepted views as to the origin and development of suns with their dependent planetary systems; and the gradual dissipation of the energy which during this process of concentration has largely taken the form of light and radiant heat. Follow out the theory to its obvious conclusions, and it becomes plain that the stars now visibly incandescent are those in mid-journey between the nebulæ from which they sprang and the frozen darkness to which they are predestined. What, then, are we to think of the invisible multitude of the heavenly bodies in which this process has been already completed? According to the ordinary view, we should suppose them to be in a state where all possibilities of internal movement were exhausted. At the temperature of interstellar space their constituent elements would be solid and inert; chemical action and molecular movement would be alike impossible, and their exhausted energy could obtain no replenishment unless they were suddenly rejuvenated by some celestial collision, or traveled into other regions warmed by newer suns.

This view must, however, be profoundly modified if we accept the electric theory of matter. We can then no longer hold that if the internal energy of a sun were as far as possible converted into heat either by its contraction under the stress of gravitation or by chemical reactions between its elements, or by any other inter-atomic force; and that, were the heat so generated to be dissipated, as in time it must be, through infinite space, its whole energy would be exhausted. On the contrary, the amount thus lost would be absolutely insignificant compared with what remained stored up within the separate atoms. The system in its corporate capacity would become bankrupt—the wealth of its individual constituents would be scarcely diminished. They would lie side by side, without movement, without chemical affinity; yet each one, howsoever inert in its external relations, the theater of violent motions, and of powerful internal forces.

Or, put the same thought in another form. When the sudden appearance of some new star in the telescopic field gives notice to the astronomer that he, and perhaps, in the whole universe, he alone, is witnessing the conflagration of a world, the tremendous forces by which this far-off tragedy is being accomplished must surely move his awe. Yet not only would the members of each separate atomic system pursue their relative course unchanged, while the atoms themselves were thus riven violently apart in flaming vapor, but the forces by which such a world is shattered are really *négligeable* compared with those by which each atom of it is held together.

In common, therefore, with all other living things, we seem to be practically concerned chiefly with the feebler forces of nature, and with energy in its least powerful manifestations. Chemical affinity and cohesion are on this theory no more than the slight residual effects of the internal electrical forces which keep the atom in being. Gravitation, though it be the shaping force which concentrates nebulæ into organized systems of suns and satellites, is trifling compared with the attractions and repulsions with which we are familiar between electrically charged bodies; while these again sink into insignificance beside the attractions and repulsions between the electric monads themselves. The irregular molecular movements which constitute heat, on which the very possibility of organic life seems absolutely to hang, and in whose

transformations applied science is at present so largely concerned, can not rival the kinetic energy stored within the molecules themselves. This prodigious mechanism seems outside the range of our immediate interests. We live, so to speak, merely on its fringe. It has for us no promise of utilitarian value. It will not drive our mills; we can not harness it to our trains. Yet not less on that account does it stir the intellectual imagination. The starry heavens have from time immemorial moved the worship or the wonder of mankind. But if the dust beneath our feet be indeed compounded of innumerable systems, whose elements are ever in the most rapid motion, yet retain through uncounted ages their equilibrium unshaken, we can hardly deny that the marvels we directly see are not more worthy of admiration than those which recent discoveries have enabled us dimly to surmise.

Now, whether the main outlines of the world-picture which I have just imperfectly presented to you be destined to survive, or whether in their turn they are to be obliterated by some new drawing on the scientific palimpsest, all will, I think, admit that so bold an attempt to unify physical nature excites feelings of the most acute intellectual gratification. The satisfaction it gives is almost esthetic in its intensity and quality. We feel the same sort of pleasurable shock as when from the crest of some melancholy pass we first see far below us the sudden glories of plain, river and mountain. Whether this vehement sentiment in favor of a simple universe has any theoretical justification I will not venture to pronounce. There is no *a priori* reason that I know of for expecting that the material world should be a modification of a single medium, rather than a composite structure built out of sixty or seventy elementary substances, eternal and eternally different. Why, then, should we feel content with the first hypothesis and not with the second? Yet so it is. Men of science have always been restive under the multiplication of entities. They have eagerly noted any sign that the chemical atom was composite, and that the different chemical elements had a common origin. Nor, for my part, do I think such instincts should be ignored. John Mill, if I rightly remember, was contemptuous of those who saw any difficulty in accepting the doctrine of 'action at a distance.' So far as observation and experiment can tell us, bodies *do* actually influence each other at a distance. And why should they not? Why seek to go behind experience in obedience to some *a priori* sentiment for which no argument can be adduced? So reasoned Mill, and to his reasoning I have no reply. Nevertheless, we can not forget that it was to Faraday's obstinate disbelief in 'action at a distance' that we owe some of the crucial discoveries on which both our electric industries and the electric theory of matter are ultimately founded; while at this very moment physicists, however baffled in the quest for an explanation of gravity, refuse altogether to content themselves with the belief, so satisfying to Mill, that it is a simple and inexplicable property of masses acting on each other across space.

These obscure intimations about the nature of reality deserve, I think, more attention than has yet been given to them. That they exist is certain; that they modify the indifferent impartialitiy of pure empiricism can hardly be denied. The common notion that he who would search out the secrets of nature must humbly wait on experience, obedient to its slightest hint, is but partly true. This may be his ordinary attitude; but now and again it happens that observation and experiment are not treated as guides to be meekly followed, but as witnesses to be broken down in cross-examina-

tion. Their plain message is disbelieved, and the investigating judge does not pause until a confession in harmony with his preconceived ideas has, if possible, been wrung from their reluctant evidence.

This proceeding needs neither explanation nor defence in those cases where there is an apparent contradiction between the utterances of experience in different connections. Such contradictions must of course be reconciled, and science can not rest until the reconciliation is effected. The difficulty really arises when experience apparently says one thing and scientific instinct persists in saying another. Two such cases I have already mentioned; others will easily be found by those who care to seek. What is the origin of this instinct, and what its value; whether it be a mere prejudice to be brushed aside, or a clue which no wise man would disdain to follow, I can not now discuss. For other questions there are, not new, yet raised in an acute form by these most modern views of matter, on which I would ask your indulgent attention for yet a few moments.

That these new views diverge violently from those suggested by ordinary observation is plain enough. No scientific education is likely to make us, in our unreflective moments, regard the solid earth on which we stand, or the organized bodies with which our terrestrial fate is so intimately bound up, as consisting wholly of electric monads very sparsely scattered through the spaces which these fragments of matter are, by a violent metaphor, described as 'occupying.' Not less plain is it that an almost equal divergence is to be found between these new theories and that modification of the common-sense view of matter with which science has in the main been content to work.

What was this modification of common sense? It is roughly indicated by an old philosophic distinction drawn between what were called the 'primary' and the 'secondary' qualities of matter. The primary qualities, such as shape and mass, were supposed to possess an existence quite independent of the observer; and so far the theory agreed with common sense. The secondary qualities, on the other hand, such as warmth and color, were thought to have no such independent existence, being, indeed, no more than the resultants due to the action of the primary qualities on our organs of sense-perception; and here, no doubt, common sense and theory parted company.

You need not fear that I am going to drag you into the controversies with which this theory is historically connected. They have left abiding traces on more than one system of philosophy. They are not yet solved. In the course of them the very possibility of an independent physical universe has seemed to melt away under the solvent powers of critical analysis. But with all this I am not now concerned. I do not propose to ask what proof we have that an external world exists, or how, if it does exist, we are able to obtain cognisance of it. These may be questions very proper to be asked by philosophy; but they are not proper questions to be asked by science. For, logically, they are antecedent to science, and we must reject the sceptical answers to both of them before physical science becomes possible at all. My present purpose requires me to do no more than observe that, be this theory of the primary and secondary qualities of matter good or bad, it is the one on which science has in the main proceeded. It was with matter thus conceived that Newton experimented. To it he applied his laws of motion; of it he predicated universal gravitation. Nor was the case greatly altered when science became as much preoccupied with the movements of molecules as it was with those of planets. For molecules and atoms, what-

ever else might be said of them, were at least pieces of matter, and, like other pieces of matter, possessed those 'primary' qualities supposed to be characteristic of all matter, whether found in large masses or in small.

But the electric theory which we have been considering carries us into a new region altogether. It does not confine itself to accounting for the secondary qualities by the primary, or the behavior of matter in bulk by the behavior of matter in atoms; it analyses matter, whether molar or molecular, into something which is not matter at all. The atom is now no more than the relatively vast theater of operations in which minute monads perform their orderly evolutions; while the monads themselves are not regarded as units of matter, but as units of electricity; so that matter is not merely explained, but is explained away.

Now the point to which I desire to call attention is not to be sought in the great divergence between matter as thus conceived by the physicist and matter as the ordinary man supposes himself to know it, between matter as it is perceived and matter as it really is, but to the fact that the first of these two quite inconsistent views is wholly based on the second.

This is surely something of a paradox. We claim to found all our scientific opinions on experience; and the experience on which we found our theories of the physical universe is our *sense-perception* of that universe. That *is* experience; and in this region of belief there is no other. Yet the conclusions which thus profess to be entirely founded upon experience are to all appearance fundamentally opposed to it; our knowledge of reality is based upon illusion, and the very conceptions we use in describing it to others, or in thinking of it ourselves, are abstracted from anthropomorphic fancies, which science forbids us to believe and nature compels us to employ.

We here touch the fringe of a series of problems with which inductive logic ought to deal, but which that most unsatisfactory branch of philosophy has systematically ignored. This is no fault of men of science. They are occupied in the task of making discoveries, not in that of analyzing the fundamental presuppositions which the very possibility of making discoveries implies. Neither is it the fault of transcendental metaphysicians. Their speculations flourish on a different level of thought; their interest in a philosophy of nature is lukewarm; and howsoever the questions in which they are chiefly concerned be answered, it is by no means certain that the answers will leave the humbler difficulties at which I have hinted either nearer to or further from a solution. But though men of science and idealists stand acquitted, the same can hardly be said of empirical philosophers. So far from solving the problem, they seem scarcely to have understood that there was a problem to be solved. Led astray by a misconception to which I have already referred; believing that science was concerned only with (so-called) 'phenomena,' that it had done all that it could be asked to do if it accounted for the sequence of our individual sensations, that it was concerned only with the 'laws of nature,' and not with the inner character of physical reality; disbelieving, indeed, that any such physical reality does in truth exist;—it has never felt called upon seriously to consider what are the actual methods by which science attains its results, and how those methods are to be justified. If anyone, for example, will take up Mill's logic, with its 'sequences and co-existences between phenomena,' its 'method of difference,' its 'method of agreement,' and the rest; if he will then compare the actual doctrines of science with this version of the mode in which those doc-

trines have been arrived at,—he will soon be convinced of the exceedingly thin intellectual fare which has been hitherto served out to us under the imposing title of Inductive Theory.

There is an added emphasis given to these reflections by a train of thought which has long interested me, though I acknowledge that it never seems to have interested anyone else. Observe, then, that in order of logic sense-perceptions supply the premises from which we draw all our knowledge of the physical world. It is they which tell us there *is* a physical world; it is on their authority that we learn its character. But in order of causation they are effects due (in part) to the constitution of our organs of sense. What we see depends not merely on what there is to be seen, but on our eyes. What we hear depends not merely on what there is to hear, but on our ears. Now, eyes and ears, and all the mechanism of perception, have, as we know, been evolved in us and our brute progenitors by the slow operation of natural selection. And what is true of sense-perception is of course also true of the intellectual powers which enable us to erect upon the frail and narrow platform which sense-perception provides, the proud fabric of the sciences.

Now natural selection only works through utility. It encourages aptitudes useful to their possessor or his species in the struggle for existence, and, for a similar reason, it is apt to discourage useless aptitudes, however interesting they may be from other points of view, because, being useless, they are probably burdensome.

But it is certain that our powers of sense-perception and of calculation were fully developed ages before they were effectively employed in searching out the secrets of physical reality—for our discoveries in this field are the triumphs but of yesterday. The blind forces of natural selection, which so admirably simulate design when they are providing for a present need, possess no power of prevision, and could never, except by accident, have endowed mankind, while in the making, with a physiological or mental outfit adapted to the higher physical investigations. So far as natural science can tell us, every quality of sense or intellect which does not help us to fight, to eat, and to bring up children, is but a by-product of the qualities which do. Our organs of sense-perception were not given us for purposes of research; nor was it to aid us in meting out the heavens or dividing the atom that our powers of calculation and analysis were evolved from the rudimentary instincts of the animal.

It is presumably due to these circumstances that the beliefs of all mankind about the material surroundings in which it dwells are not only imperfect but fundamentally wrong. It may seem singular that down to, say, five years ago, our race has, without exception, lived and died in a world of illusions; and that its illusions, or those with which we are here alone concerned, have not been about things remote or abstract, things transcendental or divine, but about what men see and handle, about those 'plain matters of fact' among which common sense daily moves with its most confident step and most self-satisfied smile. Presumably, however, this is either because too direct a vision of physical reality was a hindrance, not a help, in the struggle for existence; because falsehood was more useful than truth; or else because with so imperfect a material as living tissue no better results could be attained. But, if this conclusion be accepted, its consequences extend to other organs of knowledge besides those of perception. Not merely the senses, but the intellect, must be judged by it; and it is hard to see why evolution, which has so lamentably failed to produce trustworthy instruments for obtaining the

raw material of experience, should be credited with a larger measure of success in its provision of the physiological arrangements which condition reason in its endeavors to turn experience to account.

Considerations like these, unless I have compressed them beyond the limits of intelligibility, do undoubtedly suggest a certain inevitable incoherence in any general scheme of thought which is built out of materials provided by natural science alone. Extend the boundaries of knowledge as you may; draw how you will the picture of the universe; reduce its infinite variety to the modes of a single space-filling ether; retrace its history to the birth of existing atoms; show how under the pressure of gravitation they became concentrated into nebulæ, into suns, and all the host of heaven; how, at least in one small planet, they combined to form organic compounds; how organic compounds became living things; how living things, developing along many different lines, gave birth at last to one superior race; how from this race arose, after many ages, a learned handful, who looked round on the world which thus blindly brought them into being, and judged it, and knew it for what it was—perform, I say, all this, and, though you may indeed have attained to science, in nowise will you have attained to a self-sufficing system of beliefs. One thing at least will remain, of which this long-drawn sequence of causes and effects gives no satisfying explanation; and that is knowledge itself. Natural science must ever regard knowledge as the product of irrational conditions, for in the last resort it knows no others. It must always regard knowledge as rational, or else science itself disappears. In addition, therefore, to the difficulty of extracting from experience beliefs which experience contradicts, we are confronted with the difficulty of harmonizing the pedigree of our beliefs with their title to authority. The more successful we are in explaining their origin, the more doubt we cast on their validity. The more imposing seems the scheme of what we know, the more difficult it is to discover by what ultimate criteria we claim to know it.

Here, however, we touch the frontier beyond which physical science possesses no jurisdiction. If the obscure and difficult region which lies beyond is to be surveyed and made accessible, philosophy, not science, must undertake the task. It is no business of this society. We meet here to promote the cause of knowledge in one of its great divisions; we shall not help it by confusing the limits which usefully separate one division from another. It may perhaps be thought that I have disregarded my own precept—that I have wilfully overstepped the ample bounds within which the searchers into nature carry on their labors. If it be so, I can only beg your forgiveness. My first desire has been to rouse in those who, like myself, are no specialists in physics, the same absorbing interest which I feel in what is surely the most far-reaching speculation about the physical universe which has ever claimed experimental support; and if in so doing I have been tempted to hint my own personal opinion that as natural science grows it leans more, not less, upon an idealistic interpretation of the universe, even those who least agree may perhaps be prepared to pardon.

A. J. Balfour.

---

*SCIENCE AND THE PEOPLE.**

Opportunities beget responsibilities. On such an occasion as this, he who has been honored with the opportunity is tempted to address you upon a specialized subject to which he has given years of thought and

* Retiring address of the president of the North Carolina Academy of Science, Wake Forest College, May 13, 1904.

interest, but the opportunity carries with it corresponding responsibilities beyond the narrow bounds of one's limited investigations. The audience is composed in part of the general public, which is more or less informed, or misinformed through no self-fault, as to the general trend of scientific thought and movement; in part of students, some enwrapt with the beauty and majesty of ancient art and philosophy, others versed in the history of science and conversant with its latest conceptions; in part, my hearers are specialists in the varied branches of science, so I feel much like Moleschott in his address at the reopening of the University of Rome, when he found himself 'in the face of an audience whom he had nothing to teach, but from whom he had much to learn.'

The groundwork of science may be thrown into three divisions: (1) laborers who work; (2) tools they must employ; and (3) that which constitutes the fields of their labors.

In the world we know there is such a thing as progress; that civilization is dependent upon something capable of increase, evidently knowledge. Although, as Schiller has said, 'Knowledge is to one a goddess, to another an excellent cow,' yet the momentum of progress is largely, if not altogether, given by science.

Variations in social conditions have caused variations in human standards of morality, but through all the ages morality has actually been a stationary thing. Different ages have known mighty things in literature and art, but each was the individual outcome of the pen or brush of the genius, who bequeathed a heritage of his own labors as a stimulus to others; but the mastership passed with him. Not so with science; for, as Whewell has said, 'It is not a collection of miscellaneous, uncorrected, unarranged knowledge that can be considered as constituting science.'

Different ages have known mighty things in science, sometimes as the outcome of a genius, but equally as often the consequence of talent building upon that which was learned before. So, never was one more mistaken than President Woodrow Wilson when he stated that science breaks with the past.

In order to appreciate the spirit of modern science, we must take a hurried glance at the motives prompting the older workers and consider their environment. We are aware, in the historical development of things, that all present knowledge arose from a chaotic state enveloping itself in mystery. This was due to the empirical means of observation, superstition attending any inquiry into the why of things, hampering circumscriptions of religions, primitive and more recent, and lack of means of communication. The wise man, exercising a little common sense, wrought cures wonderful in those dark times, many simple for the youngest practitioner of to-day. While, doubtless, some were prompted by an earnest desire to do good, many were actuated by greed of power and gain, even as to-day. Fearful of their loss once secured, they often sought to hide their own shortcomings and take advantage of the universal ignorance by their mysticism. These were not the sole motives of all workers, however. The spirit of inquiry has ever been present with mankind. For

> Ignorance is the curse of God,
> Knowledge the wings wherewith we fly to heaven.

Although, three hundred years before Christ, the living and dead were dissected at the Alexandrian School, it was not until the fifteenth century that the popes overcame popular prejudice about the sanctity of the dead body and issued edicts permitting dissection. The following century, Vesalius arose, and then Harvey discovered the circulation of the blood. Greek philos-

ophers first endeavored to place science upon a purely rational basis and they were accused of impiety. To be sure, it may be said that such impeachments have not ceased to sound for over two thousand years and cost the lives of many good and noble men. The church considered Galileo and similar workers as rank heretics. Certain scientific endeavors were tolerated, and the knowledge gained confined within monastic walls. In the hearts of some was that yearning to make known the truths they had dreamed; and monks like Roger Bacon, Basil Valentine and Berthold Schwartz put forth writings so mysterious as to be incomprehensible to many, but having hidden realities not previously made known.

Science was centuries acquiring its natural voice. In the dark ages only a small band of learned folk made itself known, yet the voice of Kepler, saying 'The scientist's highest privilege is to know the mind and to think the thoughts of God,' sounded three centuries ago, has echoed with increasing reverberations to our own time. Science, harassed by ding-dong, useless and unnecessary authority, was driven into rigid pious paths. As the very spirit of science is inquiry, it lives upon liberty and would not be bound by authoritative misconceptions. It is not strange, then, that in a democracy of thought permitting the widest range of opinions men should have been borne away to the other extreme, and such catching expressions as 'every one for himself and no god for any one' became prevalent. 'Scientific arrogance' was a pet expression of theologians who trespassed none the less than had the scientists. 'The abuse heaped upon Newton for substituting blind gravitation for an intelligible Deity' that John Fiske tells about, was nothing in comparison with the subsequent treatment of geologists by theologians for disturbing the Biblical chronology. The highest teaching of scientific verities is the absolute necessity for the existence of God. In fact, one need not go far for a chemical confirmation of the resurrection, as death is but a phase of our continual internal change; 'so when this corruptible shall have put on incorruption and this mortal shall have put on immortality,' our natural body sown in dishonor and weakness, shall be raised a spiritual body, clothed in glory and power; 'and as we have borne the image of the earthly, we shall also bear the image of the heavenly.' It is only in the most modern times that the scientific spirit, which looks to the relative and temporarily excludes the absolute, has begun to be fully applied and extended to ideas of every order.

I am by no means unmindful of the dogmatism of science at times, for it may be recalled that Daguerre was actually temporarily incarcerated in an asylum because he maintained he could transfer his likeness to a tin plate; Franklin's paper on lightning conductors was laughed at and not published by the Royal Society; and Galvani was attacked by his colleagues, designated a know-nothing, and called 'the frog's dancing master.' The Count de Gasparin even wrote in the *Journal des Débats*, 'Take care; the representations of the exact sciences are on their way to become the inquisitors of our days.'

Science does not pretend to say the last word in regard to the universe, but it builds hypotheses upon observed and unobserved facts which are altered or cast aside in the light of all new correctly obtained facts. It is ever ready to declare the increasing uncertainty of many delightful and ideal conceits, which is not to be taken as vacillation, but as evolution, growth. The late distinguished Lord Playfair at the Aberdeen meeting of the British Association said: "The changing theories which the world despises are the leaves of the tree of science drawing nutriment to the parent

stems, and enabling it to put forth new branches and to produce fruit; and, though the leaves fall and decay, the very products of decay nourish the roots of the tree and reappear in the new leaves or theories which succeed." With this spirit, it will not hesitate to attack any of our pet scientific, sociological or theological dogmas, which are frail as all human systems must be. These attacks are without venom, however, for "Science * * * requires for its satisfactory prosecution the employment of our very noblest powers, and it is by them alone that we can hope to attain a knowledge of the most supreme and ultimate truths which our intellectual faculties have the power to apprehend."—(Mivart.)

Although Gough remarked to Dalton, 'The human mind is naturally partial to its own conceptions and frequently condescends to practise a little self-delusion when obliged by the force of facts and arguments to abandon a favorite notion,' the supreme lesson in the history of science, most marked in our own time, is the pursuit of truth. Much time has been spent in defining *art* and casting that which did not fit a pet definition into a rubbish box called *science*, or 'natural knowledge' as a member of the Royal Society was pleased to term it. Many of those insisting upon such a classification are not without reason, for have not certain phylogenetics promulgated on the flimsiest excuse some *pan mixia*, as Weismann's germ-plasm theory and then easily remembering the conclusions, but forgetful of the evidence, maintained that it was a law? Or has not a Tesla over magnanimously taken the public into his confidential conversations with the inhabitants of Mars?

It has been fashionable in years gone by to say that poetry and truth were antagonistic. Coleridge and Poe, I think, insisted that science and poetry were irreconcilable. Incongruous statements, as when Shakespeare speaks of a toothache 'as humor or a worm,' doubtless gave rise to such thoughts. The Avon poet put it according to the scientific teachings of his time. Civilization and methods of interpreting the truth change and progress, but truth itself is eternal. Science will no more replace literature than can a geometric diagram be substituted for a landscape painting.

Science, to be sure, is destructive of conventions. Freedom is the breath of science, and the unshackled movement of boundless human curiosity must affect literature. Men of science look not pleasantly upon their scavenging camp followers, who, riotous in thought, indulge in a license of speech which provokes quite justly those who conscientiously differ from them, and unfortunately inculcates ideas in those unable to winnow the chaff from the grain.

Thus it may be seen that modern science makes for purity and genuineness. There is nothing more abhorrent to a man of science than the pretenses of a scientific mountebank. This elevation is dual in its effect, general and local. As an evidence of the former there have resulted ameliorated conditions of society by protecting food from harmful adulterations, improved sanitation, better and more reasonable treatment for diseases, general distribution of the products of wealth among all civilized peoples, and in many other ways too numerous to mention. A reader after Count Tolstoy and his 'recognition of the bankruptcy of experimental science,' can not but be impressed with his earnestness, and yet feel that he looks only very close at home when he writes: "The men of science of our time think and speak and the crowd follows them, while at the same time there was never a period or a people among whom science in its complete significance stood on so low a level as our science to-day. One part of it, that which

should study what makes life of man good and happy, is occupied in justifying the existing evil conditions, while another part spends its time solving questions of idle curiosity." He does not apparently realize that science promotes a certain continuity of ideas, as well as the intellectual and moral education of the nations.

> There exist, indeed, and always will exist, many deplorable things, much suffering, and much wickedness in the world; but it is to the credit of science that, instead of lulling mortals with the feeling of their powerlessness into passivity of resignation, it has urged them to react against destiny, and has taught them the sure way by which they can diminish the sum of woe and injustice, and increase their happiness and that of their fellows. It has not accomplished this by means of verbal exhortations or *a priori* reasoning, but by virtue of processes and words really efficacious, because they are acquired from the study of conditions of existence and the causes of evil.

Further, as the editor of *The Popular Science Monthly* has said:

> The advance of science is evidenced in numberless ways, but our weightiest proof of it is found in the gradual acceptance of enlarged in place of narrower views of the subject. New discoveries are important; the widening of the ranges of research is important; the extension of generalization and better organization of positive knowledge are important; but more important still is the growing general recognition that science is the grand agency in modern times for reshaping the common opinions of the community.

The local elevating effect of work in pure science is the taking a man away from the sordid things of the world, and

> No life can be pure in its purpose, and strong in its strife,
> And all life not be purer and stronger thereby.

By this I would not be understood as placing him who works only in pure science on a pedestal, or intimate that he is superior to the other who makes a practical outcome of his scientific work the main object. I am well aware of the eloquent statements about this being an industrial age and the duty of young men to seek a technological education. Far be it from my purpose to exhibit the least antagonism to the general spirit of such appeals, for I endeavor to teach much of the same thing, but in it all and with it all, I would urge that the pure science be either kept ahead or abreast of commercial progress. Neither the pure nor the practical deserves to be developed alone. They are inter-dependent and have always grown together. The pure research has been utilized later in practise. Industrial demands have stimulated investigation. Illustrations abound. The destiny of nations has been changed by scientific investigations prompted either by search for research sake or by a commercial call. The history of indigo reads like a novel, for chemists have accomplished the task, not of producing artificial indigo, but the genuine indigo by artificial means. The modern spirit of pure science thus elevates man's ideals and that of the applied adds to his comfort, pleasure and happiness.

In advocating Du Bois Reymond's 'Hellenism' or the love of humanistic and scientific culture for its own sake, apart from all considerations of profit and advantage, I would not be understood as

> Nourishing a youth sublime
> With the fairy tales of science.

While I maintain that the dollar should not be the guiding star, there is no objection to dwelling upon the practical value of science; for, as Huxley has said: "It has become obvious that the interests of science and industry are identical; that science can not make a step forward without, sooner or later, opening up new channels for industry; and, on the other hand, that every advance of industry facilitates those experimental investigations upon which the growth of science depends."

It is well understood by those who have knowledge of the problem that the first line

of defense in industrial warfare is the educational centers. We are a great industrious and prosperous nation. Prosperity is the possession 'of enlarging opportunities to secure the gratification of our material, intellectual, social and spiritual wants.'

In the foregoing I have endeavored to show that science is an evolution. In the past, to be sure, at times it has marched with crippled steps; at present it is gripped into the vitals of nations. The modern spirit of science towards religion is sane and healthy; towards literature it leans in offering themes alive and seeking graceful modes for its expression; it fosters and grows with industry, so 'to choke the fountains of science is to dry the source of our prosperity.'

The progress of science among us very largely depends, as Draper has said, on two elements: first, our educational establishments; and second, our scientific societies.

School men within the past decade have learned that it is proper to send the whole boy to school and little by little science has come into the curriculum. There is room for much more sane science and its more widespread teaching, and it should be better taught. Let us teachers then have more to do with pushing the proper recognition of science before the attention of school boards, insisting upon adequate compensation, and let us have men and women ready-equipped for the work. Pardon a personal illustration. I use it solely because I know whereof I speak. Every year there go out from our laboratory at the university a dozen or more graduates who, with rare exceptions, and they are mainly my own assistants, are offered positions in other states. We can change this, and I take it as one of the things this academy may hold out for its accomplishment. How?

We teachers can and must get out and see the schools, confer with the boards, speak to the people, in short, see that wholesome works in science are placed in the libraries, tell of common sense hygiene, assist the great work and create like things to the farmers' institutes, popularize science. There is ' no discredit in popularizing science,' as Mendenhall has said, 'that popularizing what is not science is the thing that is to be shunned and avoided.'

This brings to our immediate attention the instructors in the various institutions that are making the teachers, making the preachers, the lawyers, the doctors, business men and the citizens. Boards of trustees must be made to clearly understand that time and equipment for these things must be had; boards of trustees must be made to understand that the best teachers are those who contribute something to that subject they would have better known and appreciated; boards of trustees must be impressed with the fact that with our present arrangements, most researchers must steal the time necessary from rest, sleep, social concernments and family pleasures and that it is not right, it is not just to make them mere teaching machines.

There is no question whatever but that many of the teachers in our institutions do the treadmill. All of this can not with justice be laid at the doors of our honorable governing bodies, however, for teachers are vain as other mortals. Some insert in catalogues a vast array of special courses, which either are solely for show, or, if they be given, of necessity, can not be with that fresh vigor which should characterize instruction. The man who does that voluntarily loves not really his science. It is far wiser to offer a few courses, give them well and contribute a bit, even a mite, to the sum of knowledge. I do not know but that the late Professor Rowland was a bit severe, yet I wish to quote from an address of his on a 'Plea for Pure Science.' Some chil-

dren may be coaxed, others require whipping.

It is useless to attempt to advance science until one has mastered the science; he must step to the front before his blows can tell in the strife. Furthermore, I do not believe anybody can be thorough in any department of science, without wishing to advance it. In the study of what is known, in the reading of the scientific journals, and the discussions therein contained of the current scientific questions, one would obtain an impulse to work, even though it did not before exist. And the same spirit which prompted him to seek what was already known, would make him wish to know the unknown. And I may say that I never met a case of thorough knowledge in my own science, except in the case of well-known investigators. I have met men who talked well, and I have sometimes asked myself why they did not do something; but further knowledge of their character has shown me the superficiality of their knowledge. I am no longer a believer in men who could do something if they would, or would do something if they had a chance. They are imposters. If the true spirit is there, it will show itself in spite of circumstances.

Your speaker wishes to plead with his southern colleagues for greater activity in research. Many have told me they had no appliances. Liebig had none at first and later bought most of that which he had from his slender stipend; Priestley utilized a lens and the sun's heat and discovered oxygen; Wöhler distilled potassium, using a bent gun barrel as a condenser in Berzelius's laboratory. Where there's a will, there's a way. There is so much unknown, so much to learn, and, as Victor Meyer has said, then there is 'the gaining of gold from rubbish.'

Yes, our equipment is meager; poorer than it ought to be for states now far richer than ever in their history; grown rich, too, as a result of the progress of industries. Science sowed the seed of the present prosperity and it is worthy of remembrance, thanks, reward. And these will come. In a measure, they have come. Every scientific man in the state takes pride in the growth of the new biological building at this institution, the beneficent generosity of a prominent trustee at Trinity College in equipping the physics department, the conduct of the soil survey under the direction of the Department of Agriculture, the Beaufort laboratory, etc.

The importance of promoting science as the duty of the states was well known to the ancients, especially to the Greeks and Arabs. The Prince Consort, in an address before the British Association in 1859, made the following statement:

We may be justified in hoping * * * that the legislature and the state will more and more recognize the claims of science to their attention; so that it may no longer require the begging-box, but speak to the state like a favored child to its parents, sure of his paternal solicitude for its welfare; that the state will recognize in science one of its elements of strength and prosperity, to foster which the clearest dictates of self-interest demand.

The endowment of any laboratory in any institution of the state but helps the others. There is no such thing as competition in doing good. The blanket of ignorance may be lifted a bit higher here than there, but each lifts and gives the fresh air of knowledge to those smothering beneath.

So, my friends, in fulfilling the responsibilities begotten of the honor, allow me in closing to give my conception of the destiny of this academy.

Man depends much for his happiness upon the sympathy of those around him; 'it is rare to find one with courage to pursue his own ideals in spite of his surroundings.' So science thrives best where societies exist for its advancement. Science speaks a universal language and knows no geographical, political or social boundaries, otherwise Humphry Davy would never have been so cordially entertained by his French colleagues when the shores of England and France bristled with bayonets in bloody antagonism. Then let us thank God for the brotherhood of science, for

true science, the spirit of modern science, is at war with war. The right spirit of science is that of patient inquiry; of longing for the truth, cost what it may in brain power, energy, money or self-denial; it is the spirit of cooperation as wide as the needs of man; of constructive effort through slow accretions by many laborers in many lands through many years. "The touch of science makes the whole world kin."

CHAS. BASKERVILLE.
UNIVERSITY OF NORTH CAROLINA.

DEFLECTION OF THE MISSISSIPPI.

THE theoretical effects of the earth's rotation in deflecting the courses of streams have been discussed by several investigators, among whom are Baines, von Baer, Bertrand, Buff and Gilbert. The deflecting force being persistent and the time during which it acts practically unlimited, the sufficiency of the cause has been repeatedly maintained. So far, however, the discussion has been almost purely theoretical, few actual measurements of relative bank-cutting having been made. This note attempts to present certain qualitative and quantitative data that may have some bearing on the subject. The work was done at Harvard University under direction of Professor W. M. Davis.

The Mississippi River Commission published in 1900 a set of maps which record surveys of two different dates—that of 1883 and that of 1896. The former survey is printed in black, the latter in red. Thus the changes which have occurred in an interval of thirteen years are clearly and accurately recorded and make measurements possible of the relative amounts of right and left cutting.

The part of the river course so surveyed and mapped lies between Rosedale (below Helena, Ark.) and Bayou Goula Bend (below Natchez, La.). It may be divided into two distinct sections. The first lies between Rosedale and Vicksburg and is in that part of the river's course which here swings diagonally across the flood-plain from the bluffs of the Arkansas upland on the west to the bluffs of the eastern upland in Mississippi. The second is between Vicksburg and Bayou Goula Bend, along the eastern side of the flood-plain, where it is rather sharply limited by the bluffs against which the river impinges at ten different places. The two sections are roughly of the same length, when measured along the general course of the stream.

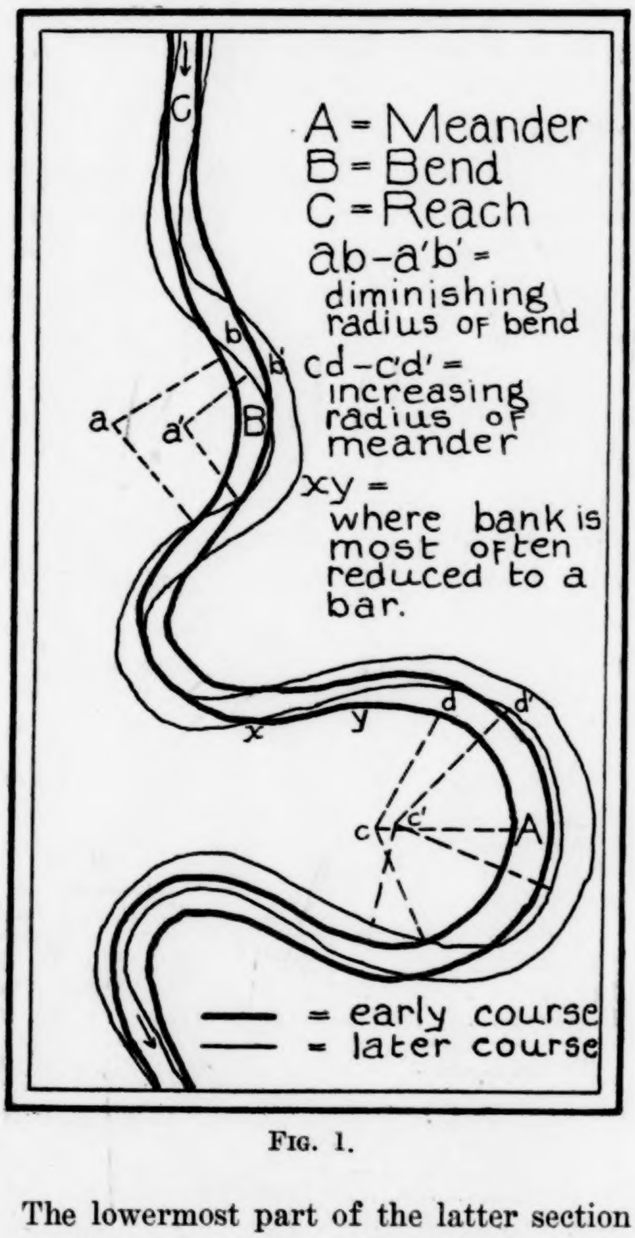

FIG. 1.

The lowermost part of the latter section—the part lying between Port Hudson and Bayou Goula Bend—has been in recent

years so well defended by revetments that the course has here remained practically unchanged for thirteen years. It is above this point, in that part of the river's course which has not been so completely restrained artificially, that significant results must be looked for. Before presenting the results of my map studies, it is desirable to explain certain terms as illustrated in Fig. 1.

By 'bend' (Fig. 1, *B*) in a river channel is meant a curve whose lateral changes involve a decrease of radius; by 'meander' (Fig. 1, *A*) a curve whose lateral changes involve a steady increase of radius until a cut-off occurs or changes elsewhere in the channel induce a disturbance here. This distinction grew out of the difference in kinds and amounts of cutting at the two sets of curves. It is evident from an examination of the maps and the generalized conditions represented in Fig. 1 that as meanders develop, the relatively straight stretches in the river's course will be continuously shortened and there will be a corresponding increase in the length of that part of the course included within the meanders. As this change progresses the radius of curvature is reduced from infinity to a finite quantity, the reduction continuing until the neck is as small as any other part of the lobe. From this time on the same tendency which ultimately produces a cut-off between alternate meanders operates to the enlargement of the radius of curvature, not only throughout the meander between them, but at the place where a cut-off occurs as well. The oxbow lakes have for this reason a longer average radius of curvature than an equal number of present meanders. The reaches (Fig. 1, *C*) include those wavering parts of the river's course the further development of which can not be accurately foretold, although it can be shown that the reaches usually develop into bends and the bends grow into meanders. It is in the reaches that there is the greatest difficulty of navigation, islands and bars occurring irregularly, for, lacking a dominant tendency, the energies of the stream are not bent in a relatively permanent and definite direction which would result in a part of the channel being maintained at a somewhat constant depth, as is the case where in consequence of the development of bends and meanders, the threads of the stream pursue a less erratic course.

The following tables contain a detailed list of areas of lateral cutting expressed

TABLE I.

Classified Measurements of Areas Cut on the Right Side and on the Left Expressed in 250ths of a Sq. M. Sheets 13 to 17 Inclusive.

	Left.					Right.				
	Bank.	Bar.	Isl'd.	Bank-bar.	Sub-T.	Bank.	Bar.	Isl'd.	Bank-bar.	Sub-T.
Meanders	2626	432	578	39	3675	3054	473	0	30	3131
Bends	2349	398	126	248	3121	1774	411	131	10	2326
Reaches	492	165	0	107	764	235	441	120	40	1262
Totals	5467	995	704	394	7560	5063	1325	251	80	6719
Sheets 18 to 25 Inclusive.										
Meanders	1943	490	0	90	2523	2378	73	140	102	2693
Bends	1841	453	0	114	2498	2370	189	0	244	2803
Reaches	390	211	60	183	844	1795	70	0	417	2282
Totals	4174	1154	60	387	5865	6543	332	140	763	7778
Gr. Totals (13–25)	9641	2149	764	781	13425	11606	1657	391	843	14497

TABLE II.

LENGTH AND AVERAGE WIDTH OF AREAS CUT EXPRESSED IN 50THS OF A SQ. M.

SHEETS 13 TO 17 INCLUSIVE.

	Left.				Right.			
	Length.		Av. Width.		Length.		Av. Width.	
	Bank.	Bar.	Bank.	Bar.	Bank.	Bar.	Bank.	Bar.
Meanders	212	55	112	53	226	45	98	37
Bends	197	79	106	52	183	55	86	34
Reaches	62	31	41	22	97	63	34	52
Totals	471	165	259	127	506	163	218	123
SHEETS 18 TO 25 INCLUSIVE.								
Meanders	140	50	81	45	188	11	91	11
Bends	235	55	98	43	226	35	156	39
Reaches	104	26	37	25	155	16	83	7
Totals	479	131	216	113	569	62	330	57
Gr. Totals (13–25)	950	296	475	240	1075	225	548	180

in two-hundred-and-fiftieths of a square mile and classified with respect to reaches, bends and meanders in the two sections of the river.

The first column of Table I. gives the amount of bank cutting; the second column the amount of bar cutting. Island cutting is counted right or left, as the island lies on the right or left side of the line of deepest channel. The fourth column gives the amount of cutting involved in changing a bank to a bar. This measurement is necessarily somewhat indefinite. The subtotals in column five allow easy comparison of cutting in meanders, bends and reaches. The totals, on the other hand, furnish means for rougher comparison, although it is thought that, undifferentiated as totals must always be, it is well to examine the different sets of data separately. By a careful system of checking, the percentage of error in the measurements was found to be but little more than one per cent. Bar-cutting in every case but one is less on the side on which there is the greater bank cutting. In the more finely subdivided records from which the sub-totals in this table were made up, this fact comes out even more strongly. In the bends there is a greater area of bar removed per length of area cut or per length and area of bank removed than is removed in the meanders.

It would seem that the most significant figure in the whole table is 3,054—representing the amount of bank cutting in meanders on the right side of the river. It exceeds the corresponding figure on the left side by more than 16 per cent. It is in this part of the channel that the diverting tendency due to rotation gives its greatest support to the maximum selective influence on velocities developed here under centrifugal force. Moreover, it is in this part of the river's course that the effect of wind-waves in concealing the deflective tendency is least, but a part of a right-handed meander running at right angles to the direction of the prevailing winds. In the bends and reaches (sheets 13–17) the left-handed cutting is in excess, as if the winds here overcame the effect of the earth's rotation.

Although the Mississippi wears its channel as much on one side as on the other, this fact does not contradict the theory of deflection. The direction of flow in the Mississippi is such that any tendency to excess of right-handed over left-handed

cutting may be overcome in part, in whole, or may even be exceeded by the effect of the westerlies on the surface of the stream. If the river flowed north these two forces would combine to produce an effect that might be thought to be greatly in favor of the argument for deflection. In reality it would offer no better example than the Mississippi with its present direction of flow. In the former case the operation of the force would be less visible, but the proof of the existence of the force would be no less clear.

The best examples of deflection in these latitudes must, therefore, be sought among streams flowing neither north nor south, but in the line of the winds—east or west. The deflective tendency will, of course, be as strong under the latter conditions as under the former, while the effect of the westerlies will be distributed over right-handed and left-handed curves alike. When a larger number of measurements of cutting on such streams have been made and the wind effect and deflective tendency

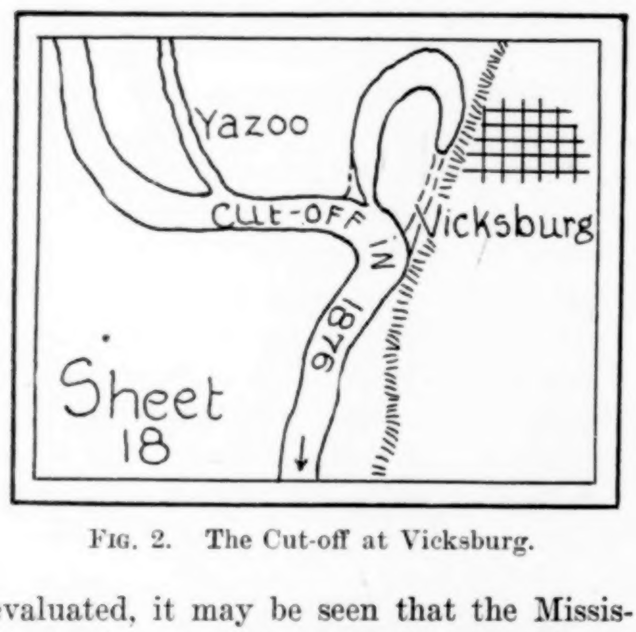

Fig. 2. The Cut-off at Vicksburg.

evaluated, it may be seen that the Mississippi offers as good proof of such tendency as any river we can find. The resolution of forces in such a manner as to produce a negative effect is no less interesting than the resolution of those same forces in producing a positive effect. A volcanic cone gradually and continuously building in mid-ocean at a rate which just counteracts the attack of the sea does not impress the geographer less than the loftier cones of similar origin more favored by position and climatic conditions.

Attention is called to the fact that between Rosedale and Vicksburg there are four cut-offs on the right and an equal number on the left side. Between Vicksburg and Bayou Goula Bend there are five on the right side and but one on the left, and that at Vicksburg, the dividing point between the two sections. This cut-off, as shown in Fig. 2, seems to have been possible only because of the direct way in which the river swings toward the bluffs from its previously free course on the open

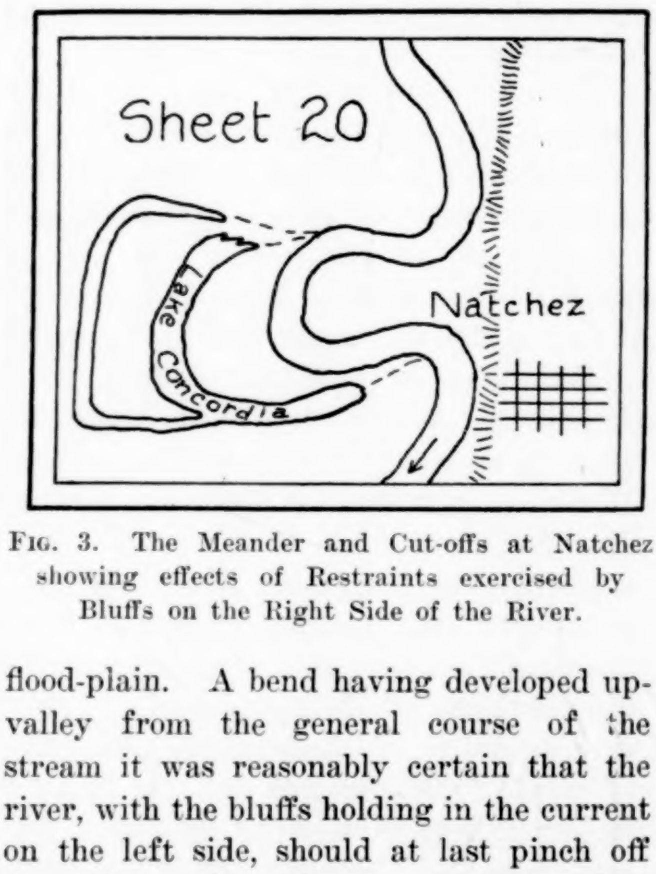

Fig. 3. The Meander and Cut-offs at Natchez showing effects of Restraints exercised by Bluffs on the Right Side of the River.

flood-plain. A bend having developed up-valley from the general course of the stream it was reasonably certain that the river, with the bluffs holding in the current on the left side, should at last pinch off the lobe and produce a cut-off; while farther down stream, where the general course of the river is close to the bluffs, cut-offs are just as certain to occur on the right side.

This restraining influence of the bluffs is brought out in the table. Below Vicksburg the right-handed cutting is notably in excess. Here the number of cut-offs is likewise in excess on the right side of the stream. A typical case of restraint may be seen at Natchez (Fig. 3), where the development of the left-handed curve is hindered while that on the right is free. As a result of these conditions and the down-valley migration of the meanders the river has twice cut through the neck of the lobe and is now increasing the radius of its present curve preparatory to a third cut-off. In stretches which have nothing but free flood-plain on both sides, a right-handed curve could not develop without an accompanying left-handed curve—a fact which can be more readily appreciated when it is remembered that, except for the down-valley movement of the meander as a whole, the center of the growing curve on the open flood-plain is relatively fixed, and the extension and development of sympathetic curves in adjacent parts of the channel are necessary attendants of the growth of the meander.

The foregoing serves to show that on the Mississippi, cut-offs as well as relative bank cutting should be counted as right or left not over the course as a whole but in sections which depend for their individuality, in part at least, upon conditions external to the river and not directly related to deflective tendency.

In conjunction with Professor M. S. W. Jefferson, of the Michigan State Normal College, the writer has undertaken measurements of this kind in Michigan along the River Rouge between its headwaters and Detroit. The river flows to the east through a plain of glacial and lacustrine origin which, on account of its level nature, offers advantages not possessed by the Mississippi. The latter stream, by cutting into a bluff, on one side, and into flood-plain deposits, on the other, does not enable one to use the maps previously mentioned in determining the absolute amount of work accomplished on the two sides of the stream. The areal expression of such cutting is no basis for the determination of the actual amount performed. The river may be doing even more work on the bluffs along its eastern bank than it accomplishes on the western bank. The River Rouge has incised itself in a level plain and in the process of deepening and widening its valley swings against bluffs of the *same* height on opposite sides of the valley.

During the summer of 1903 and in connection with hydrographic work for the U. S. Geological Survey I had the opportunity to examine most of the streams on Long Island with respect to the visible effects of deflection, and although many of the valleys on the south side of the island have a noticeably unsymmetrical development, one bank being steeper than the other, an actual count of the valleys from Montauk Point to Far Rockaway shows such a small majority of valleys asymmetrically developed and with the right bank steeper than the left, that in this case the argument based on deflective tendency does not appear well-grounded. The cuesta-like arrangement of the slopes on the island and the consequent great disparity of stream lengths, velocity and persistence throughout the year, precludes fruitful comparison of valleys on the northern and southern sides of the island as showing in how far the difference in composition of wind force and deflective tendency affects the fashioning of the valley slopes.

ISAIAH BOWMAN.

YPSILANTI, MICH.

SCIENTIFIC BOOKS.

Lehrbuch der Physik; Zweiter Band. Von O. D. CHWOLSON, St. Petersburg; übersetzt von H. Pflaum. Braunschweig, Friedrich Vieweg und Sohn. 1904. Pp. 1056.

The first volume of the German edition of

Chwolson's 'Physics,' covering the general subject of mechanics so far as this is required as an introduction to general physics, was reviewed by the present writer not quite a year ago in SCIENCE. The second volume, covering the subjects of sound and radiant energy, abundantly justifies the very favorable opinion at that time expressed. The author keeps before him a well-defined object, the preparation of a text-book for students, but not a handbook for specialists. The aim is that the student may find what he needs, and also that he may need what he finds. The student's standpoint is continually occupied, though it is assumed that no student would feel prepared to undertake the mastery of such a book in four large volumes without having previously mastered at least the elements of the subject as set forth in ordinary preparatory school work. Nevertheless, in such work it is not uncommon for the elementary student to reach a standpoint that interferes with his subsequent attainment of a comprehensive view. For example, light rays, heat rays and chemical rays are even yet supposed often by beginners to be different in kind, and the gap between these and electric rays is hard to bridge.

Chwolson undertakes the task of setting the student initially on the right standpoint, and of guarding specially against what his experience has shown him to be the most frequent misconceptions. Mathematics is not avoided, but no unnecessary complexities are ever introduced. Indeed, it would be hard to find a book in which good arrangement and accurate statement are attained with so little in the way of mathematical difficulties, though no one need expect to attack any of the problems of physical optics without having to grapple with equations that require thought.

Rather less than the first seventh of the present volume is devoted to the subject of sound. It begins with a chapter on the velocity of propagation of a disturbance in an elastic medium, in which the well-known formula for both longitudinal and transverse vibrations is deduced with unusual simplicity. The last few pages are given to the physical basis of music, which is treated only in outline. In the development of the natural scale the exclusive standard recognized is the French normal $A = 435$, at present adopted as an international musical standard. Now that König is dead, the Chladni standard, $C = 256$, so extensively employed by him for standard forks, may quite probably pass away, as Stuttgardt pitch, $C = 264$, has already disappeared, despite its use by Helmholtz in the 'Tonempfindungen.'

In the introduction to the general subject of radiant energy Chwolson goes at once into an exposition of electric radiation, closing the chapter with an enumeration of five divisions based on wave-length, and with a brief reference to 'neue Strahlen,' the rays connected with the names of Röntgen, Becquerel and Curie. These are still so little known that he does not feel warranted in linking the treatment of them with that of radiations of measurable wave-length.

The phenomena of luminescence are treated as a special transformation of energy quite apart from those of calorific radiation. Specially good and up to date is the discussion of the rate of emission of a black body as a function of temperature and wave-length. The laws of Stefan and Wien are considered, and the conclusion expressed that Stefan's law is thoroughly reliable, but is applicable only to the total radiation of an absolutely black body. The expressions for radiation of special wave-length obtained by Weber, Paschen, Wien, Thiessen, Rayleigh, Planck and Lummner and Jahnke are all considered, and as the result of comparison a preference is expressed for that of Planck (1900). The effect of radiation as pressure upon the surface of an absolutely black body, suspected as long ago as 1754 by DuFay, was first proved experimentally in 1900 by P. Lebedew, whose apparatus is shown and explained. Due credit is given to Nichols and Hull (1901), who have measured this pressure and obtained results that accord well with the requirements of theory. The application to the phenomena of comets is expressed by the statement that the theory is capable of affording a full explanation of the observed forms of comets' tails. E. F. Nichols's great improvements upon the sensitiveness of the

radiomicrometer, and his measurement of the energy radiated from certain stars and planets, are properly acknowledged.

The chapter on optical instruments is excellent. It is followed by one on the eye, which furnishes a satisfactory summary of what is of chief interest in physiological optics to the physicist. This includes a brief discussion of the telestereoscope of Helmholtz, and the more recent double telescope by Zeiss for the perception of a distant object in relief. Interesting developments are the stereotelemeter, stereo-micrometer and stereo-comparator of Pulfrich. This last instrument finds a new and unexpected field of application to the heavenly bodies. Assume that on two successive evenings photographs of Saturn are taken, using the comparator with camera attachment. During the interval of a day the position of the planet with regard to the stars has changed, as well as the position of the satellites with regard to their primary. Let these two photographs be arranged to form a stereograph and viewed binocularly either with a stereoscope or with the unaided eyes if suitably trained. Against the black background are seen the distant stars. Suspended independently in mid space between foreground and background is the planet. Behind it on one side is a satellite, and on the other side is another satellite just emerging from eclipse. Spatial relations are as distinct as if all were within arm's length. A stereograph of this kind from proofs secured by Wolf at the Heidelberg observatory is one of several that are presented for the reader's scrutiny. The instrument has been applied to the discovery of planetoids, of variable fixed stars, and to the study of such as have considerable proper motion.

The last part of the volume, relating to optical phenomena in the atmosphere, interference of light, diffraction, polarization, double refraction, interference of polarized beams and the turning of the plane of polarization by quartz and other bodies optically active, is well up to the standard of the earlier part. The value of the book is greatly enhanced by the clear cut summaries of important conclusions, and the bibliographic list of references to the literature of the subject with which each chapter is closed.

W. Le Conte Stevens.

DISCUSSION AND CORRESPONDENCE.

PALEOZOIC SEED PLANTS.

In my short note in Science of July 1 proposing the name *Pteridospermaphyta* for this group of plants, I assumed that all interested in the subject were acquainted with the facts and the literature, and I expressly refrained from entering into details. It seems that I was mistaken in this assumption, otherwise I could hardly have been misunderstood.

When in 1897 Potonié founded the group Cycadofilices,* he based it on the internal structure and classed it under the Pteridophyta with the same rank as the Filices. It included *Næggerathia,* the Medullosæ, *Cladoxylon, Lyginopteris, Heterangium* and *Protopitys.* Later he worked the same subject over for Engler and Prantl's 'Natürliche Pflanzenfamilien.'† He here says that the groups Sphenopterides, Percopterides and Neuropterides might perhaps be better included in the Cycadofilices, although he continues to class them with the ferns. He now includes *Calamopitys* in this group. M. R. Zeiller in 1900‡ discussed these forms, and although he admitted that the characters then known approached more closely those of cycads than of ferns, he says it would be rash to exclude them from the latter on these characters alone, that they may represent a special type of Filicineæ, provided with secondary wood, and that indications of fructification observed on certain fronds of *Alethopteris, Odontopteris* and *Neuropteris* may be adduced in favor of this hypothesis.

In the first preliminary paper of Drs. Oliver and Scott§ they show that *Lyginodendron,* which Potonié classes in the Lepidodendraceæ,

* 'Lehrbuch der Pflanzenpalaeontologie,' p. 160 (Lief, 2, dated 1897).

† Teil I., Abt. 4, pp. 780–795 (Lief. 213 dated 1902).

‡ 'Eléments de Paléobotanique,' pp. 124 ff., 370.

§ 'On *Lagenostoma Lomaxi,* the seed of *Lyginodendron,*' *Proc. Roy. Soc.*, Vol. LXXI., pp. 477–481.

almost certainly bore the seeds called *Lagenostoma Lomaxi* by Williamson. Toward the close of this paper they make the following significant remark: "It is not likely that *Lyginodendron* stood alone in this; we must now be prepared to find, what has long been recognized as a possibility, that many of the plants grouped under Cycadofilices already possessed seeds, and thus that a considerable proportion of the so-called 'fern-fronds' of the Palæobotanist really belonged to Spermatophyta."

Following quick upon this discovery came that of Mr. Kidston of a specimen of *Neuropteris heterophylla* bearing a rhabdocarpous seed.* The second preliminary paper of Drs. Oliver and Scott† does not mention Kidston's discovery, but deals, like the first, with the seed of *Lagenostoma Lomaxi.* In this paper, however, they say: "There are many indications that other genera, now grouped under Cycadofilices, had likewise become seed-bearing plants. It is proposed to form a distinct class, under the name Pteridospermæ, to embrace those Paleozoic plants with the habit and much of the internal organization of ferns, which were reproduced by means of seeds. At present, the families Lyginodendreæ and Medulloseæ may be placed, with little risk of error, in the new class, Pteridospermæ." Putting this with the remark above quoted from their previous paper, it seems clear that this new class is regarded as belonging to the Spermatophyta as coordinate with the Gymnospermæ and Angiospermæ.

In a paper presented to the Paris Academy of Sciences by M. Grand'Eury on March 7, 1904,‡ he mentions the numerous seeds found associated with the Neuropterideæ and gives his reasons for believing that they were borne by those plants, and he remarks that 'from all this it evidently does not follow that the Neuropterideæ are primitive Cycadineæ, but this solution is the more probable as the stipes of these ferns resemble in a striking manner *Colpoxylon* and *Medullosa.*'

* *Op. cit.*, Vol. LXXII., December 29, 1903, p. 487.

† *Op. cit.*, Vol. LXXIII., pp. 4–5.

‡ *Comptus Rendus*, Vol. CXXXVIII., pp. 607–610.

At the next session of the academy (March 4), M. R. Zeiller made a communication on the mode of fructification of the Cycadofilicineæ. Commenting on the facts set forth by Grand-'Eury and the discoveries of Kidston and Oliver and Scott, he says: "We thus find ourselves in the presence of types manifestly related on the one hand to the ferns, on the other to the Cycadineæ, and we can hardly refuse to see in this group of the Cycadofilicineæ or Pteridospermæ, to use the name proposed by MM. Oliver and Scott, one of the principal steps in the process of evolution which must have led from the one to the other; but we have already to do here with true Gymnosperms, and the establishment of this fact leads to a profound modification in our knowledge of the Carboniferous flora.*

Still more significant are certain statements made by M. B. Renault relative to the Paleozoic flora of Autun in a paper presented to the academy on May 16, 1904. He says: "With the stems of *Calamodendron* and *Arthropitys* and their branches we have met with small cylindrical seeds several millimeters long (Stephanospermum); the proximity of the seeds and branches may permit the assumption of some relationship (*parenté*) between them. * * * From the facts above set forth it seems to follow that the Cryptogams may have had several points of contact with the Phanerogams; the Colpoxylons remind us of the Cycads and Ferns; *Arthropitys* of the Equisetaceæ and the Conifers; and finally the seeds of *Gnetopsis* recall those of the Gnetaceæ.†

M. Grand'Eury returned to this subject in the session of July 4, 1904, and gave reasons for believing that several of the genera formerly regarded as ferns, including *Linopteris*, were seed-bearing, and that the small striate seeds associated with *Neuropteris flexuosa* from the Department of the Gard were borne by that species. He entered somewhat into the discussion of the numerous

* *Comptes Rendus*, Vol. CXXXVIII., p. 664.

† *Comptes Rendus*, Vol. CXXXVIII., p. 1239. This paper was republished in the ***Procès-Verbaux de la Société d'Histoire naturelle d'Autun***, Année 1904.

seeds that have been found at St. Etienne and in other parts of France, and the probable connection of a considerable portion of them with these fern-like genera.*

About the last work done by Adolphe Brongniart was the elaboration of the collections of these silicified seeds, the results of which were published posthumously in a large monograph.† In the light of recent discoveries this work assumes special importance. From such an examination as I was able to make in 1900, in company with M. Potonié and under the guidance of M. Grand'Eury, of the beds of St. Etienne, from which most of these seeds were obtained, I conclude that it is doubtful whether any will be found there attached to stems or fronds, but some may be so found, and, as we have seen, they are being so found in other places.

These and other considerations which need not be introduced here have led me to the conclusion that the plants in question should not be classed either as Pteridophyta or as Spermatophyta, but should be regarded as constituting a distinct phylum intermediate between the two, for which I proposed the name Pteridospermaphyta. The three great types to which the Paleozoic seed plants, exclusive of recognized Gymnosperms, either have proved or are likely to prove to be allied are the Ferns, the Calamites and the Lepidophytes. It therefore seems probable that there will need to be recognized three corresponding classes, which should be called, respectively, the Pteridospermæ, the Calamospermæ and the Lepidospermæ. The first of these names has already been appropriately used, unless, as Potonié's classification of *Lyginodendron* in the Lepidodendraceæ would imply, that plant has its closest affinities with the Lepidophytes. In that case it would belong to the class Lepidospermæ. Those having affinities with the Calamarians or Equisetineæ, such as the Stephanosperma, believed to have been borne by *Calamodendron* or *Arthropitys*, would belong to the class Calamospermæ, while those seeds borne by plants having the foliage of ferns, such as *Neuropteris heterophylla*, would belong to the class Pteridospermæ.

If it be said that the existence of seeds necessarily places a plant in the Spermatophyta, the answer is that at the stage in plant development to which those forms belonged it will not probably prove possible to maintain any such sharp line of demarkation. The distinction between microspores and pollen has already practically broken down, and Kidston now regards the spores of *Neuropteris heterophylla* as the male inflorescence. In like manner the distinction between macrospores and seeds is likely to break down, and the attempt to retain plants of such low organization in the Spermatophyta will present grave difficulties. By establishing an intermediate phylum to which all forms may be referred as fast as the appropriate parts are discovered, all these difficulties will be removed. We should then have the following classification of vascular plants:

Phyla.	Classes.
Pteridophyta	Filicineæ. Equisetineæ. Lycopodineæ.
Pteridospermaphyta	Pteridospermæ. Calamospermæ. Lepidospermæ.
Spermatophyta	Gymnospermæ. Angiospermæ.

Lester F. Ward.

THE SOUFRIÈRE OF ST. VINCENT IN JULY, 1904.

To the Editor of Science: When the report was circulated in the daily papers of this country that Mont Pelé was in full eruption again, May 8, 1904, the second anniversary of the destruction of St. Pierre, the author wrote to correspondents in Martinique and St. Vincent for particular information as to the condition of the volcanoes which roused so much attention throughout the world two years ago. The data regarding Mont Pelé were published in Science for July 1, 1904.*

From St. Vincent comes the statement that everything has been quiet at the Soufrière since the great eruptions in the latter part of

* *Comptes Rendus*, Vol. CXXXIX., pp. 23–27.

† 'Recherches sur les Graines Fossiles Silicifiées,' par Adolphe Brongniart, Paris, 1881, fol. with 21 plates, many colored.

* Hovey, 'Mont Pelé from October 20, 1903, to May 20, 1904,' Science, N. S., Vol. XX., pp. 23–24.

March, 1903. The present condition of the volcano is shown by the following extract from a letter to the author written July 13, 1904, by Rev. Thomas Huckerby of Château Belair, St. Vincent:

The general condition of things is far different from what it was twelve months ago. At the present time there is very little emission of steam from the fissures which formed themselves in the ejecta left inside the crater after the last eruption. The surface of the lake is gradually widening, which result is brought about by the falling down of the ashy sides of the immense bowl. Large quantities of material from the top of the perpendicular windward side are falling in, which cause will ultimately bring back the gradual declivity of former years. I should say that the crater, from east to west, is considerably over a mile in diameter. There is still a very strong smell of sulphuretted hydrogen, which at times is perceptible at Château Belair. It is surprising to find that much of the vegetation especially near the base of the mountain has survived through all the adverse circumstances of the past two years; even the maroon tree is throwing out shoots from its battered and charred roots. The mongoose has found his way back to a point above the Half-Way Tree. I think that we may with safety conclude that the god Vulcan has quietened down to another period of rest as far as St. Vincent is concerned.

Mr. Huckerby also forwards a photograph of the interior of the crater which indicates not only a widening of the lake due to the falling in of the walls, but also a rise due to the accumulation of water. It is evident that the mountain is rapidly resuming its former condition and appearance under the influence of the agencies which tend towards the rapid decomposition of rock material in the tropics.

EDMUND OTIS HOVEY.
AMERICAN MUSEUM OF NATURAL HISTORY,
August 4, 1904.

SPECIAL ARTICLES.

THE INHERITANCE OF SONG IN PASSERINE BIRDS.

Further Observation on the Development of Song and Nest-building in Hand-reared Rose-breasted Grosbeaks, Zamelodia Ludoviciana (Linnæus).

In a paper published in SCIENCE, June 24, 1904,* I have recorded some observations in regard to the growth, plumage and song of hand-reared rose-breasted grosbeaks. It is the purpose of the present paper to carry these observations a step further and to describe what occurred to the birds after they were mated, as recorded in the foregoing paper.

About the third week in May, 1904, the song of the two male birds, each of which now had a mate, became crystallized and assumed a definite character, which was almost alike in both, but was absolutely and entirely different from the song of the rose-breasted grosbeak as it is heard when wild out of doors. I have had for some years in a cage one of the green bulbuls of India, known as Hardwick's bulbul, *Chloropsis hardwickii,* Jardine & Selby. This bird is singularly persistent in singing for about nine months in the year. It is a male. My two pairs of rose-breasted grosbeaks were in a cage adjacent to that of the bulbul, and by the middle of May of the present year the songs of the two male grosbeaks were so closely an imitation of the insistent song of the bulbul that it was difficult, when not looking at the birds, to tell which species was singing. I may say that the song of the green bulbul is emphatic, clear, high-pitched, rather melodious and delivered so that the whole does not occupy more time than does the song of the song sparrow, which, in a certain way, this song resembles. The song of the rose-breasted grosbeak as heard in wild birds I should describe as being like that of the robin, but more melodious and richer, and uttered with much greater deliberation. It will be perceived that the contrast between this kind of song and that of the bulbul is great. This song was constant and of daily occurrence throughout the last ten days of May and the whole of June, but ceased and was given up entirely by July 4.

During the whole of May (the pairs having mated and being in different cages), the process of mating, and later the matters of nest-building and laying were carried on as I shall now set forth. After much preliminary courting on the part of the males, which was accompanied by some severe quarrels between the mating birds, they finally became paired. These quarrels were at times so severe that it was essential to separate the birds for periods

* SCIENCE, N. S., Vol. XIX., No. 495, pp. 957–959, June 24, 1904.

of greater or less time. The strange female which I introduced to one of the males had to remain for several weeks in a small cage inside of the larger cage in which the male was confined in order to prevent the sanguinary quarrels in which the birds engaged. At times one would be the victor and again the other; but generally it was the male bird that was triumphant. The victor in every case so bullied and annoyed the vanquished that the life of the conquered birds was, for the time, rendered miserable. However, all this was remedied by time and the birds came ultimately to a satisfactory understanding.

About the middle of May it was evident that they wished to build nests; any straw or stray feather in the bottom of the cage was eagerly taken and attempts were made to place such material in some secure position. I now put branches in both of the cages, with what I considered suitable forks in which the birds might build the characteristic nests of wild grosbeaks. I also placed in the cage rootlets, straw, small sticks and twigs, in short, as nearly as I could, the same material that I found in the nests of wild rose-breasted grosbeaks. These the birds eagerly availed themselves of and for ten days or more engaged themselves most busily in abortive attempts at nest-building. They seemed unable to arrange a suitable foundation of rootlets and twigs in any of the crotches or branches I had given them, and after this thing had gone on for two weeks and no progress had been made, I determined to give them artificial nests. These were the kind of nests supplied to canary birds, being wire baskets of fine mesh into which a felting of cowhair was securely sewed.

In both cases the grosbeaks availed themselves of these nests at once and proceeded to utilize feathers and some extra cowhair that I had given them to complete the lining of the structure. In four days after receiving these nests both females began to lay; but, though each female laid a full complement of eggs, these were generally broken by the birds. The first three or four eggs laid had hard shells and after that each of the females laid several eggs with soft shells. The way that I account for the eggs being broken is that both birds of each pair, after an egg had been laid in the nest, continued their efforts to build a structure more to their liking, and that it was their claws as they trampled about that perforated the shell of the eggs already laid.

After the first laying which I have described as abortive, an interval of perhaps a week intervened, when laying began again with almost precisely the same results. All this time the males were constantly singing, courting the females, feeding them, caressing them, and the operation of treading was frequently witnessed throughout the day.

While I am not prepared to conclude that the grosbeaks would not have built a nest, if furnished with more commodious quarters and nearer like the condition of affairs that exist out of doors, I conclude that so far as nest-building in cages is concerned they are unable to accomplish anything. So far as the song is concerned I believe that they inherit the call-notes of both pleasure and fear, but that the song of the males was an imitation of the song of a bird that strongly impressed them during the period when they were cultivating this secondary sexual characteristic.

WILLIAM E. D. SCOTT.
PRINCETON UNIVERSITY,
August 8, 1904.

CURRENT NOTES ON METEOROLOGY.

UTILIZATION OF FOG.

IN the *Monthly Weather Review,* XXXII., No. 4, 1904, the suggestion is made by a writer in San Diego, Cal., that an instrument consisting of a wire frame-work be contrived, which shall collect fog particles, conduct the drops into a rain-gauge, and thus make the measurement of fog possible. The object of this measurement would be to show that in such a region as southern California, where the rainfall is small and where there is a good deal of fog, the fog deposit is a considerable one, and is of noteworthy importance to vegetation. In his comments on this suggestion, Professor Abbe rightly points out that it would be difficult, if not impossible, to argue from the catch of a fog screen to the catch of an orchard of trees; that the 'fog depositor'

would give no positive information as to how much the leaves and stems of plants collect, or how much of the water falls to the ground in such a way that the roots of the plants may utilize it, and that the chief benefit which delicate plants on the California coast obtain from the fogs is probably in the protection which the fogs afford against the heat of the sun.

CLIMATE OF SOUTH AFRICA.

J. R. Sutton, meteorologist of the DeBeers Consolidated Mines at Kimberley, South Africa, has published a paper on 'The Determination of Mean Results from Observations made at Second-Order Stations on the Tableland of South Africa' (*Rept. So. Afr. Assoc. Adv. Sci.*, Vol. I., April, 1903). The observations in Cape Colony are usually made at 8 A.M., Colony mean time, but other hours are used at other stations. It was in order that all these observations may be compared with one another that the present paper was prepared. The author has taken the observations at Kimberley, which are very complete, and has calculated from them the corrections which are needed in order to reduce the hourly means of all elements to the true means for each month and for the year.

CLIMATE OF SIERRA LEONE.

That Sierra Leone has some right to the unenviable title of 'the white man's grave' is evidenced by the fact that in the nineteenth century no less than eighteen governors or acting governors of the colony died at their posts or on their way home. This fact is brought out in a recent book on Sierra Leone by Major J. J. Crooks, who was governor at three different times ('A History of the Colony of Sierra Leone, Western Africa,' 1903). Major Crooks admits that 'in spite of sanitary arrangements now in force' the climate 'can not be said to improve greatly.'

THUNDER-STORMS AND PRESSURE.

A. J. Monné, the editor of the new Dutch meteorological journal, *Hemel en Dampkring*, has recently discussed the question of the frequency of thunder-storms under different conditions of pressure, and finds that (in Holland) thunder-storms occur most frequently when the pressure is slightly below the normal. Similar conclusions have also been reached by Prestel and Prohaska. It should, however, be noted that mountain thunder-storms often occur locally during hot, clear, anticyclonic days, when the pressure is high.

SIROCCO IN TUNIS.

Hann calls attention (*Met. Zeitschr.*, 1904, 44–45) to a temperature of 104.9° Fahr. registered at 9 P.M., August 27, 1902, at the meteorological station in Tunis. This remarkably high reading was made during a sirocco. The relative humidity at the same time was five per cent. The sirocco was accompanied by a fall of fine red dust and a few drops of warm rain.

BIRD MIGRATION IN ENGLAND.

Studies of the migration of birds made at the Kentish Lightship, in the English Channel, in the autumn of 1903, by Mr. Eagle Clarke, show that the immediate cause of the great migratory movements was a fall of temperature in the area of origin. When this fall occurs, the instinct to migrate appears to be suddenly aroused, and the movement takes place even under the most unfavorable meteorological conditions. The direction of the wind appears to have no influence.

THE WIND.

'Le Vent dans l'Antiquité' is the title of a paper by F. Hooreman, in *Ciel et Terre* for July 1, which may be of interest to many readers who are not especially concerned with meteorology. The subdivisions of this discussion are: Ancient theories regarding the origin and nature of wind; names of the winds; climatic characteristics of winds; the tower of the winds at Athens.

R. DeC. Ward.

Harvard University.

A STATION FOR THE STUDY OF BIRD LIFE.

Articles of incorporation have just been drawn looking to the establishment on a permanent foundation of the 'Worthington Society for the Investigation of Bird Life.' The

founder, Mr. Charles C. Worthington, will erect and endow, on his estate at Shawnee, Monroe County, Pennsylvania, the necessary buildings and equipment.

The Worthington Society will have for its purpose the consideration of bird life as it is found in nature, and will also have many birds under confinement for study and experiment.

The following is a summary of the chief topics that will present an immediate field for experimentation, which it is proposed by the liberality of the foundation to make continuous and exhaustive in the hope of reaching conclusive results.

1. The study and consideration of a bird as an individual. It is believed that by means of observation carried through the entire life of the individual, with a daily record, brief or elaborate, as exigencies may require, much will be learned regarding matters that are now obscure. Facts, such as growth, habits, health, temper, etc., will be daily reported.

2. The study of the occurrence, extent, nature and cause of variations in different representatives of the same species.

3. Changes in color and appearance correlating with age, sex and season.

4. Changes in color and appearance due to light, heat, presence or absence of moisture, and to food. How rapid a change in appearance can be effected by a new environment or a new set of conditions?

5. Heredity. What general characteristics are transmitted? Are acquired characteristics transmitted? The consideration of atavism, prepotency and telegony.

6. Experiments in breeding. Hybridity and the fertility of hybrids. The possibility of establishing a new physiological species.

7. Experiments in change of color due to moult.

8. Adaptability. The plasticity of animals. How great a factor is this in domesticating new kinds of animals?

9. The leisure of animals. How is this acquired? Being acquired, how is this employed?

10. Instinct, habit and the development of intelligence.

11. The possibility of breeding insectivorous and other beneficial kinds of birds to restock a given region or to increase native birds, as has been done in the case of fish, by the United States Fish Commission.

A temporary laboratory and aviary is being equipped, and preliminary work will begin with the installment of a large number of native and foreign birds early in September. Mr. Worthington has procured the services of Mr. William E. D. Scott, Curator of the Department of Ornithology at Princeton University, as director of the proposed work. Mr. Bruce Horsfall has been engaged as chief assistant and artist. The corps of assistants and workers will be increased as the plans of the Worthington Society develop.

SCIENTIFIC NOTES AND NEWS.

Dr. S. Weir Mitchell, of Philadelphia, has been elected a corresponding member of the Paris Academy of Medicine.

Dr. William Osler, professor of medicine at the Johns Hopkins University, has been appointed regius professor of medicine at the University of Oxford in the place of Sir John Burdon-Sanderson. *The Medical Record* says: "This news will be received with deep regret by a host of friends and admirers of Dr. Osler in this country, who have long looked on him as one of the leaders in American medical thought. Dr. Osler has passed all his professional life as a teacher of medicine, a vocation for which he is eminently qualified by his broad culture, profound medical learning, and an inborn gift of expression. He was born in Tecumseh, Ontario, in 1849, and was graduated in medicine from McGill University, Montreal, in 1872, For ten years, from 1874 to 1884, he was professor of the institutes of medicine at McGill, from 1884 to 1889 he was professor of clinical medicine at the University of Pennsylvania, Philadelphia, and since 1889 he has held the chair of medicine at the Johns Hopkins University, Baltimore. We beg to offer our congratulations to the new regius professor of medicine at Oxford, and at the same time to send anticipatory greetings to Sir William Osler, Bart. The Oxford School of Medicine is also and especially to be congratulated."

The Department of Agriculture at Washington is making definite arrangements concerning the work which will be carried on with the Guatemalan ants found by Mr. O. F. Cook in Guatemala to kill the cotton boll weevil. Mr. Cook has been assigned to the Bureau of Entomology for especial work on the ant, although he is to continue the personal direction of the work in tropical agriculture by the Bureau of Plant Industry. He has authority under the chief of the Bureau of Entomology to carry to completion the study of the life history of the Guatemalan ant and of such other species of ants as may be involved in order to properly understand the life history of this species. He will also direct and superintend the further introduction of the *kelep* ant from Guatemala if the same is deemed necessary, and will supervise and carry out the work connected with the colonization of the ant in the southern United States. All publications on the work will be issued by the Bureau of Entomology. Cooperation with the Bureau of Plant Industry will continue in so far as such cooperation may be useful in the utilization of the ant in practical cotton culture and in incidental studies on the varieties of cotton best adapted to support the ants, and other collateral considerations which involve problems of plant life history, plant introduction, plant breeding and plant pathology. Results of any such collaboration, where they have a botanical or plant industry bearing, are to be published by the Bureau of Plant Industry.

Until such time as a successor to the late Dr. J. B. Hatcher, as curator of paleontology in the Carnegie Museum, shall have been chosen, the work of the Section of Paleontology in that institution will be under the immediate supervision of Dr. W. J. Holland, the director of the museum.

The University of Freiburg has conferred an honorary doctorate on the anthropologist, Otto Ammon, of Karlsruhe.

Professor Blondlot, the physicist of Nancy, has been made an officer of the French Legion of Honor.

The British Medical Journal states that Professor von Esmarch, of Kiel, who recently celebrated his eightieth birthday, who was recently the victim of an accident which disabled him for a time, has now recovered and is able to take his customary walks in the environs of the town.

Professor Ewald Hering, the well-known physiologist, celebrated his seventieth birthday at Leipzig, on August 5.

Dr. Georg Thilenius, professor of anthropology at Breslau, has been appointed director of the Hamburg Museum of Ethnology.

The British Admiralty has appointed a standing committee on machinery designs, with Professor A. B. W. Kennedy, LL.D., F.R.S., as president.

The Royal College of Physicians, London, has appointed lecturers for next year as follows: The Goulstonian lecturer, Dr. W. C. Bosanquet; the Milroy, Dr. T. M. Legge; the Lumleian, Dr. W. H. Allchin; the Oliver Sharpey, Dr. L. E. Hill; the FitzPatrick, Dr. Norman Moore.

We learn from *Nature* that a statue to Jan Pieter Minckelers, the reputed discoverer of coal gas, was unveiled last month in Maastricht, Holland. Minckelers was born in 1748, and became in 1772 professor of physics in the University of Louvain, where in 1784, in endeavoring to discover a substitute for hydrogen, he succeeded in obtaining from the distillation of powdered coal a gas which he called 'inflammable air.' It was in 1785 that he first utilized the gas for lighting purposes, when a class-room in the Louvain University was illuminated by his method. He died in 1824 at the age of seventy-six years.

Dr. Joseph David Everett, F.R.S., formerly professor of natural philosophy at Queen's College, Belfast, died on August 9, at the age of seventy-three years. In 1871 Dr. Everett moved the appointment of a committee of the British Association for the selection and naming of dynamical and electrical units, and in 1873 drafted a report in which the terms 'dyne,' 'erg,' and 'C. G. S. unit' were introduced at his suggestion. His 'Illustration of

the C. G. S. System' was translated into many languages.

THE deaths are also announced of Professor Karl Weigert, director of the Laboratory of Pathological Anatomy of the Senckenburg Foundation, Frankfort on Maine, well-known for his important contributions to histology; of Dr. Friedrich Eisenlohr, associate professor of mathematics at Heidelburg, on July 21, aged seventy-three years; of Dr. Lobry de Bruyn, professor of chemistry at Amsterdam, on July 22 at the age of forty-seven years; of M. Jean Gabriel de Tarde, the author of well-known works on social psychology, at Paris at the age of sixty-one years, and of M. Robert Bieri, aged twenty-six years, recently appointed professor of natural sciences at the Berne Normal School, who was killed by an Alpine accident on August 4.

WE call attention to advertisements in SCIENCE announcing that applications are invited for the professorship of geology and mineralogy in the University of Melbourne and for the post of assistant entomologist in the Department of Agriculture, Cape Colony.

THE annual meeting of the Association of German men of science and physicians will be held at Breslau, from September 18 to 24.

THE Sixth International Congress of Zoology met at Berne from August 14 to 19. When the preliminary program was issued in July 250 members had joined the congress and 70 papers had been placed on the preliminary program. Among the papers was a discussion on recently discovered stages in the evolution of the horse and contemporary mammals in North America, opened by Professor H. F. Osborn; a paper on changes of animal cells during youth and old age, by Professor Charles S. Minot, and on peculiarities in the development of Chimaera collici, by Professor Bashford Dean.

THE Society of Chemical Industry will meet in New York, from September 7 to 12, under the presidency of Sir William Ramsay, who will give his address at Columbia University on September 8. About one hundred British members will attend the meeting. After the adjournment in New York a tour has been arranged ending at St. Louis on September 19 in time for the Congress of Arts and Science.

THE British Medical Association will meet next year in Leicester, under the presidency of Mr. G. C. Franklin. The meeting in 1906 will probably be in Toronto.

THE twelfth National Irrigation Congress will be held at El Paso, Texas, from November 15 to 18. The congress will meet in four sections, the names of which indicate that attention will be paid to popular interests. They are: 'Save the Forests,' 'Store the Floods,' 'Reclaim the Deserts' and 'Homes on the Land.'

IT is stated in *Nature* that a board of agriculture has recently been established in the Bahamas, and a botanic station is to be started in connection with it for which a curator will be required. Applications for the post should be made in the first instance to the Imperial Commissioner of Agriculture for the West Indies, Barbados.

THE field parties sent out by the Carnegie Museum in the spring in order to make paleontological collections report unusual success in the field. The party operating in Montana has succeeded in finding some valuable specimens of Triceratops. Good collections have been made in western Nebraska, and the collections of invertebrates made in New York and Canada are extensive.

INVESTIGATIONS carried on during the last year by Mr. S. W. McCallie, assistant state geologist of Georgia, acting in cooperation with the United States Geological Survey, have revealed the presence of interesting and perhaps valuable properties in some of the artesian waters in the Coastal Plain of that state. Water taken from a deep well at Baxley showed on analysis 5.5 parts per 1,000,000 of phosphoric acid, which would indicate that it might be used for fertilizing as well as for irrigating barren fields. In other words, it may be acceptable to the desert land as both food and drink. It is estimated that a layer of this phosphoric acid-bearing water 12 inches deep over one acre of land would exert a fertilizing effect equal to that of 200 pounds of commercial fertilizer.

UNIVERSITY AND EDUCATIONAL NEWS.

The New York *Evening Post* states that a canvassing committee of the alumni of the Massachusetts Institute of Technology has been formed, in connection with a plan to raise an endowment fund. It is said that $1,500,000 already has been pledged, and that every one of the thirty-seven classes graduated from the institute will be organized to contribute annually a certain fixed sum. The purpose is to make the institute independent financially, and thus check the movement for a union with Harvard.

The Drapers' Company have discharged the debt of University College, London, to the bankers to the amount of £30,000. The treasurer has received from Messrs. Wernher, Beit and Co. their check for £10,000, promised to promote the incorporation of the college in the university. For the completion of the incorporation scheme, there remains the sum of £18,000 to be raised.

The Medical Record states that recently several foreign missionary societies in this country and England agreed to establish jointly a school of high rank in China for the instruction of natives in the principles of modern medicine and surgery. In accordance with the scheme a medical college is now under construction. The cost is estimated at $50,000. Toward this the Dowager Empress has contributed about $6,000. Subscriptions are now being sought from high Chinese officials, who are expected to follow the example of the Empress. There will be a five-year course, and the school will have authority to confer the degree of doctor of medicine upon students who complete this course and pass the examination successfully. The training will be regardless of creed, but the bulk of the students at first will naturally be christians.

The total number of matriculated students during the present summer at the German universities is 39,581, against 37,881 last winter and 37,813 during the summer of 1903. Ten years ago the attendance was about 11,000 less than to-day. Eleven thousand seven hundred and seventy-five of the present students study law, 8,111 philology and history, 5,945 medicine, 5,945 mathematics or natural sciences, 2,235 evangelical theology, and 1,770 Catholic theology.

The Seminary for Oriental Languages at Berlin has, during the present summer course, 156 students. Of these, 70 are jurists, 45 are candidates for the diplomatic and consular service, 29 are scientists, teachers and members of the philosophical faculty, 18 are Government officials, merchants and private persons, 19 are officials of the Federal post-office department, 13 are army officers, 2 are physicians, 3 are theologians, and 2 are technicians. The number of foreigners is 10.

Professor A. Marston has been appointed dean and G. W. Bissell, vice-dean of the Division of Engineering of the Iowa State College, both retaining their chairs as heads of their respective departments. Professor L. E. Ashbaugh has been appointed associate professor of civil engineering and W. M. Wilson, assistant professor of mechanical engineering. A new assistant professorship of electrical engineering has been created, but the position is as yet unfilled. The last legislature has established an Engineering Experiment Station for which the trustees have appointed the following staff: A. Marston, director; G. W. Bissell, L. B. Spiney, S. W. Beyer, W. H. Meeker and the president of the college, Dr. A. B. Storms, *ex-officio*. Last year's enrollment in the engineering division of the college was 675.

Dr. H. B. Torrey has been promoted to an assistant professorship of zoology at the University of California.

J. Burt Miner, Ph.D. (Columbia), has been appointed instructor in philosophy in the University of Iowa.

The managers of the Philip Walker Fund have elected Mr. J. Henderson Smith, B.R., Balliol College, of Oxford University (M.B. Edin.), to the Philip Walker studentship for three years. This is the first election to the studentship, which has only been founded during the past year for the furtherance of original research in pathology.

Baron von Eiselberg, professor of surgery in the University of Vienna, has declined an invitation to succeed Professor König in the corresponding chair at Berlin.